



RCA INSTITUTES

INC.
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Founded 1909



Technical Lesson 56

COMMERCIAL LONG AND SHORT WAVE RECEIVERS

Type IP-501 Receiver. The Type IP-501 receiver is designed for operation as a regenerative detector circuit to receive the signals sent out by spark stations, and for regenerative beat reception to respond to continuous wave (C.W.) signals.

The vacuum tube detector is mounted on the panel with the tuning apparatus, a rear view of which is illustrated in Figure 1. The complete circuit diagram is shown in Figure 2. A front view of the panel showing the tuning controls, filament voltmeter and filament rheostat control, is illustrated in Figure 3. A schematic diagram of the IP-501 is shown in Figure 3A.

A crystal detector may be connected to the two binding posts marked "Crystal" for the reception of spark signals or modulated C.W., and the four-pole double-throw switch permits a quick changeover from crystal to vacuum tube operation. When the switch handle is in the center position, marked "Send," the receiving circuits are disconnected from the detector which should be the adjustment when signals are being transmitted.

The wavelength range of the receiver is from 300 meters to 8000 meters.

External loading inductance coils may be inserted in the primary, secondary and tickler circuits to reach the maximum range of the receiver. The "long wave loading unit" is shown mounted over the main receiver cabinet in Figure 4, while the schematic wiring diagram of this same unit is shown in Figure 5. The binding posts on both panels are placed exactly opposite to allow convenient and accurate connection between the circuits. When the loading coils are used the metal straps attached to the three pairs of binding posts on the receiver panel must be removed. Connection between the lower antenna post of the loading unit and the antenna post of the receiver is required.

A three position rotary switch on the loading unit panel connects the circuit to a low, medium and high wavelength range. When the switch is in "Low" position all of the loading coils are short-circuited and the receiver is then in a condition for the regular adjustments which are carried out when additional inductance is not used. In "Medium" position the primary and tickler coils are added to the circuit while only a portion of the secondary loading inductance is cut in. On the "High" position all of the loading coils are added to the respective circuits.

The coupling between the primary and secondary loading coils is variable, with a lock provided to hold the adjustment. The tickler coil coupling is also variable and likewise provided with a lock.

The receiver is an inductively coupled type having independent primary and secondary circuits which must be in tune with the wavelength of the signals desired.

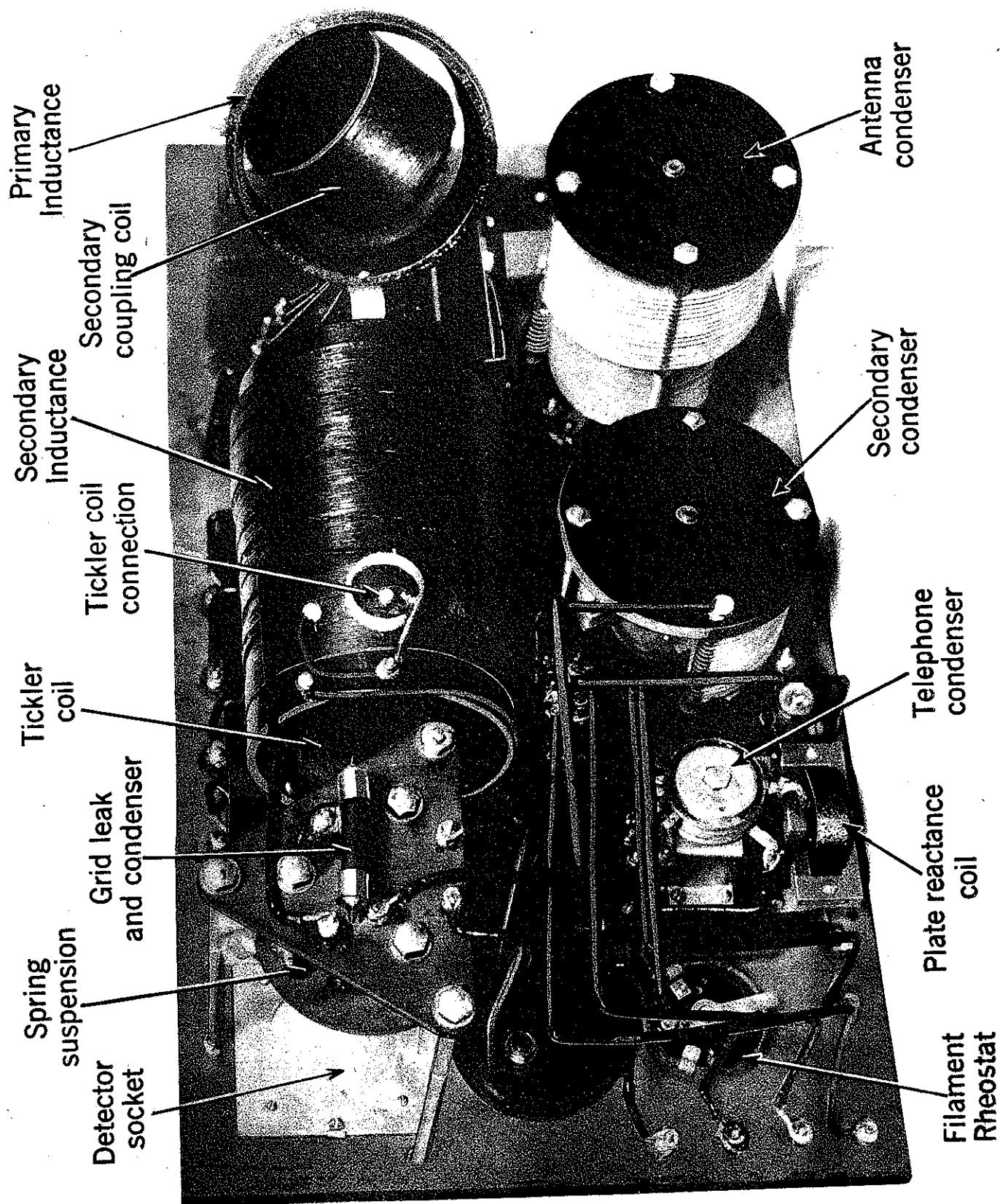


Figure 1

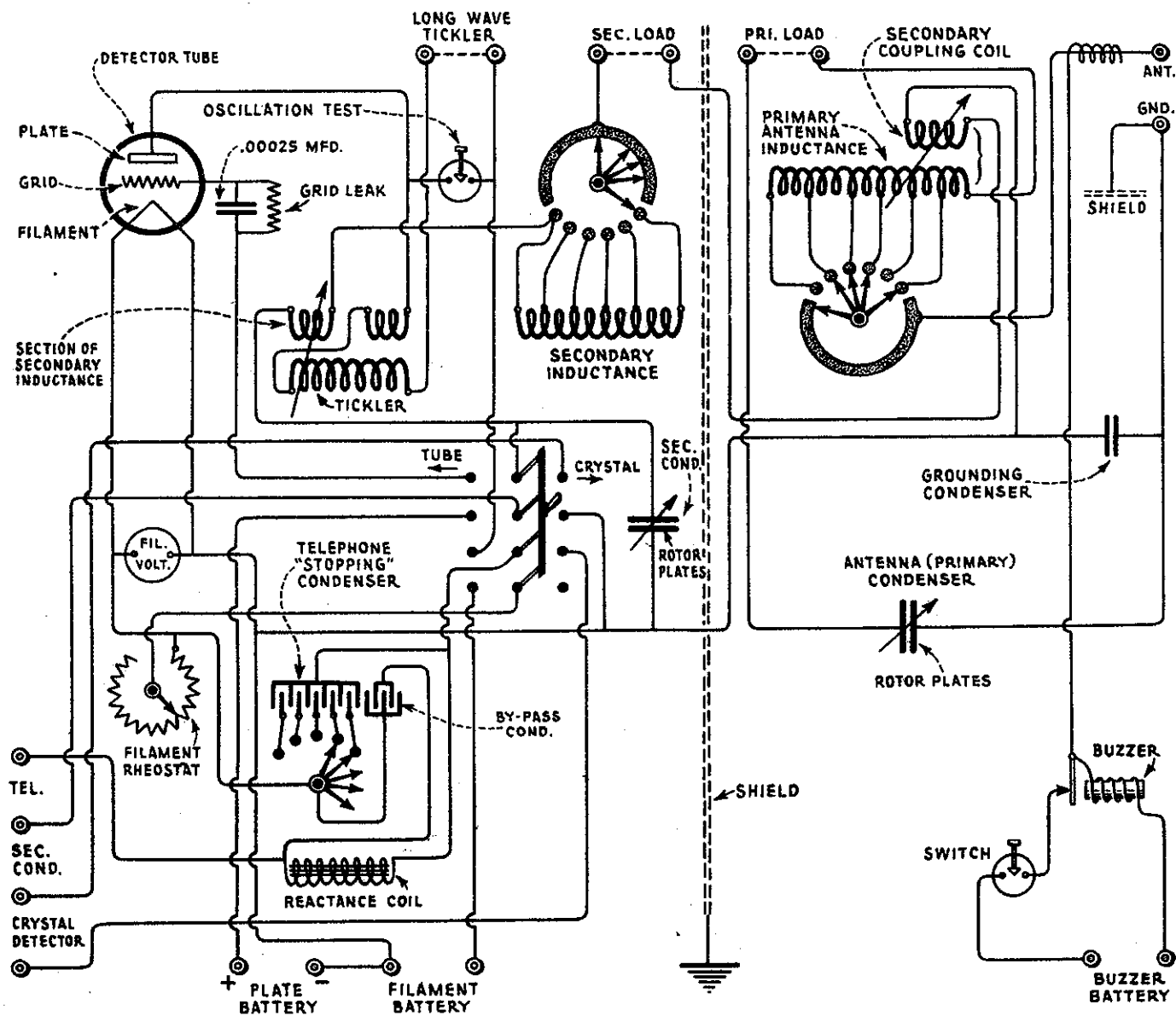


Figure 2

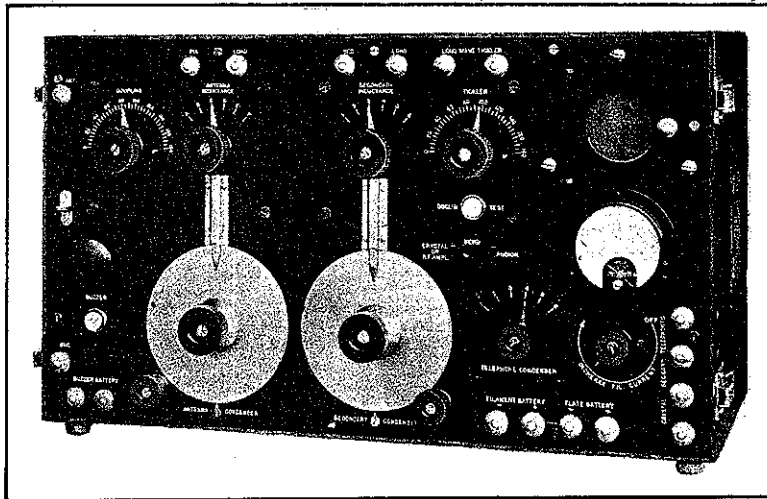


Figure 3

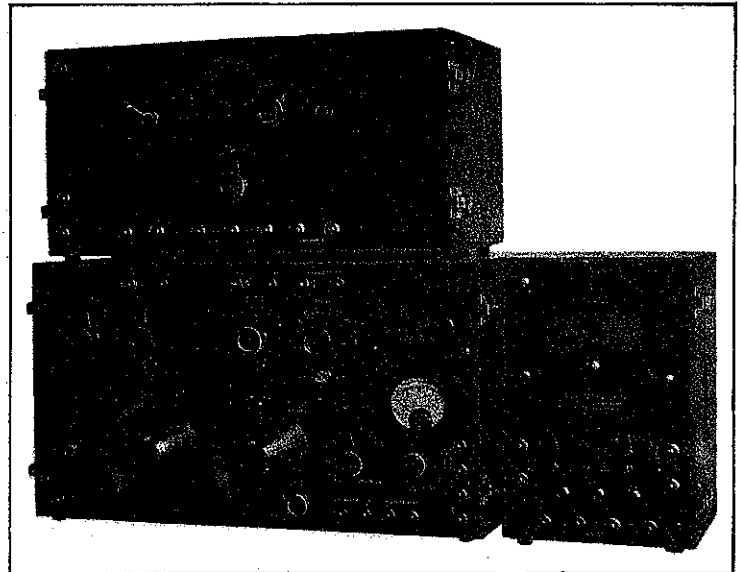


Figure 4

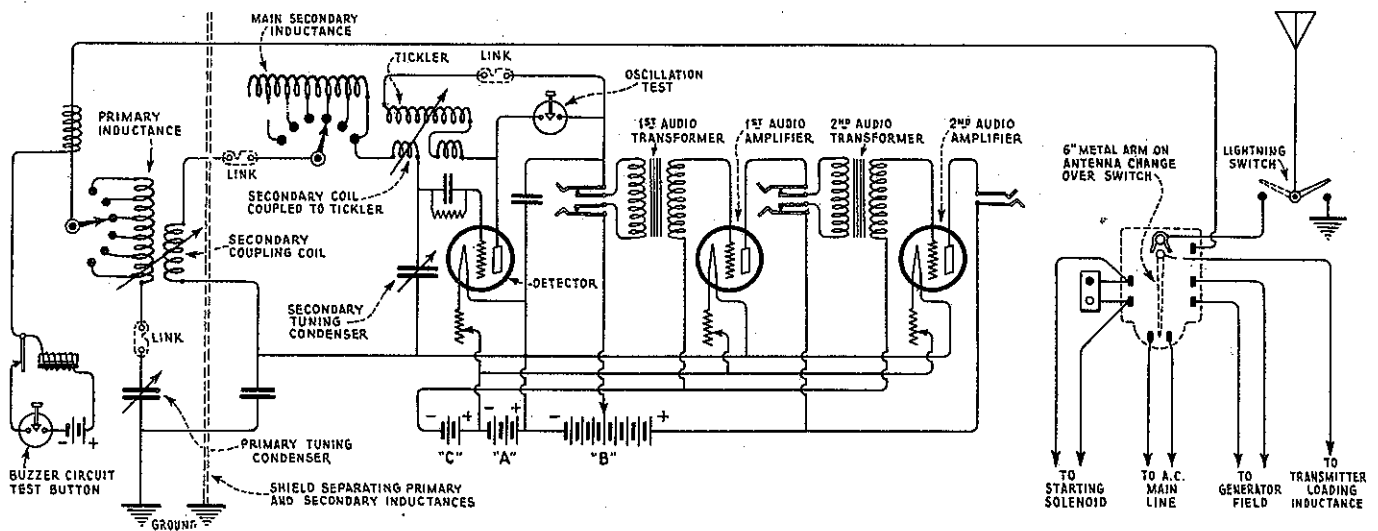


Figure 3A

To the right of the main receiver cabinet in Figure 4 is shown the two-step audio amplifier unit. Five volt tubes of the 201-A type are employed in the detector and amplifier circuits, the filaments being energized by a 6 volt storage battery. The receiver and amplifier units are electrically connected by attaching a jumper wire from each "telephone" binding post to each "input" binding post, the corresponding binding posts of the two instruments being exactly opposite. Separate filament rheostat controls are provided for each tube, and each plate circuit is equipped with a phone jack, to allow for reception of signals directly from the detector, or after the signals have passed through one or two stages of amplification.

The amplifier unit is provided with terminals for connecting the 6 volt "A" battery, the "C" battery to furnish a negative bias to the grid circuits, and the "B" battery to supply the positive plate potentials. The e.m.f. of the "B" battery may range from 90 to 135 volts, and the potential of the "C" battery should be between 4.5 and 9 volts depending upon the amount of "B" voltage used. The main receiver unit is also provided with battery terminals for the detector tube only. Leads can be connected to the filament posts from the storage battery supplying the amplifier. The "B" battery may be tapped at the 45 volt terminal and a lead carried to the "positive plate battery" binding post.

A small protective spark gap is mounted on the extreme left of the receiver panel directly in the center, and a thin card should be slipped in between the two angle-shaped posts occasionally as a test to make sure that the gap is not short-circuited.

Antenna Circuit or Primary Circuit. The antenna or open oscillatory circuit consists of the antenna, the primary cylindrical loading coil, the primary inductance bank-wound on threaded tubing, the antenna inductance switch, the variable air type condenser, and the ground conductor.

The primary inductance is tapped and made variable in six steps with connections to the rotary control switch indicated on the panel from A to F. This switch is equipped with an arrangement for dead-ending the unused portions of the inductance. The diagram shows how the end switch automatically connects and opens, or entirely disconnects and short-circuits the sections of inductance when the five switch blades make different contact with the studs.

The primary inductance is mounted at an angle to the main secondary inductance with a heavy sheet metal shield placed between the coils to neutralize electrostatic coupling effects. The coupling between the circuits is purely electromagnetic as provided by a movable coupling coil which is part of the total inductance of the secondary.

By the switch arrangement for short-circuiting the unused sections of the inductance, interference is minimized. If the unused turns were allowed to remain in the circuit the self-capacity (distributed capacity) and inductance of these turns would of themselves form an oscillatory circuit and there would be a loss of high-frequency current. At the same time the resulting magnetic field would react upon the main inductance to change its self-inductance. This would tend to destroy the resonant setting of the circuit and broaden the tuning.

The primary condenser remains in series with the antenna circuit at all times. It has a capacity of between 0.00008 mfd. and 0.0045 mfd. being also of the self-balanced type with suitable gearing to provide a vernier motion. When the condenser is rotated between 0 and 180 degrees a very fine variation in capacity is obtainable by means of the vernier control. When the inductance switch is moved, a mechanism attached to it moves a pointer to successive circles which are engraved on the condenser dial, and the wavelength calibrations may then be marked on the dial for future identification.

Secondary or Closed Circuit. The secondary oscillatory circuit consists of the secondary inductance, also bank-wound, on a form of threaded bakelite dilecto tubing. Also the secondary variable air type condenser shunted between one end of the inductance and the inductance switch, and the small coil inserted within the primary tubing which provides the coupling between both circuits. The secondary loading inductance in the "long-wave unit" becomes a part of this circuit, providing this long-wave unit is used.

The secondary inductance is tapped and made variable in six steps, the sections being added to the circuit in progressive order when the secondary inductance switch is rotated from point 1 to point 6. This switch also is equipped with the automatic arrangement for cutting out and short-circuiting the unused sections of the coil. The capacitance of the secondary condenser is rated from about 0.00006 mfd. to 0.0032 mfd. and it is also equipped with vernier control. The condenser dial is engraved with rows of concentric circles across which the pointer moves when the inductance switch is rotated, similar to the mechanical arrangement of the primary condenser.

Coupling the Primary and Secondary. The transfer of radio-frequency oscillations from the primary to the secondary is obtained by the mutual inductance between a movable coupling coil, which is part of the secondary inductance, and the low wavelength end of the primary inductance. The photograph shows the movable coil mounted within and toward one end of the primary inductance. The variable magnetic coupling between the two circuits enables the primary and secondary to be adjusted individually to a given wavelength, thus affording sharp tuning to one wavelength.

When the windings of the two coils are parallel the coupling is maximum and it is then that the induced signal oscillations reach their highest current strength, but under these conditions selectivity is reduced. If the coupling coil is rotated to occupy a position where its windings are in a plane at right angles to the primary turns then the coupling is loosest or at minimum (zero). The coupling coil may be rotated a few degrees beyond this point of zero coupling where the respective windings are at an angle of 90 degrees to what is called a small reverse coupling. By utilizing reverse coupling it is possible in practice to secure a point of minimum coupling between the primary and secondary circuits on all wavelengths within the range of the receiver.

Capacity coupling between the circuits is neutralized by means of the small reverse coupling which has the effect of sharpening the tuning considerably, and thereby reducing interference. As we have previously explained the capacity coupling between the circuits is entirely eliminated by enclosing the elements forming the primary and secondary in separate heavy sheet copper boxes. The metal sheets act as a shield in blocking and absorbing static

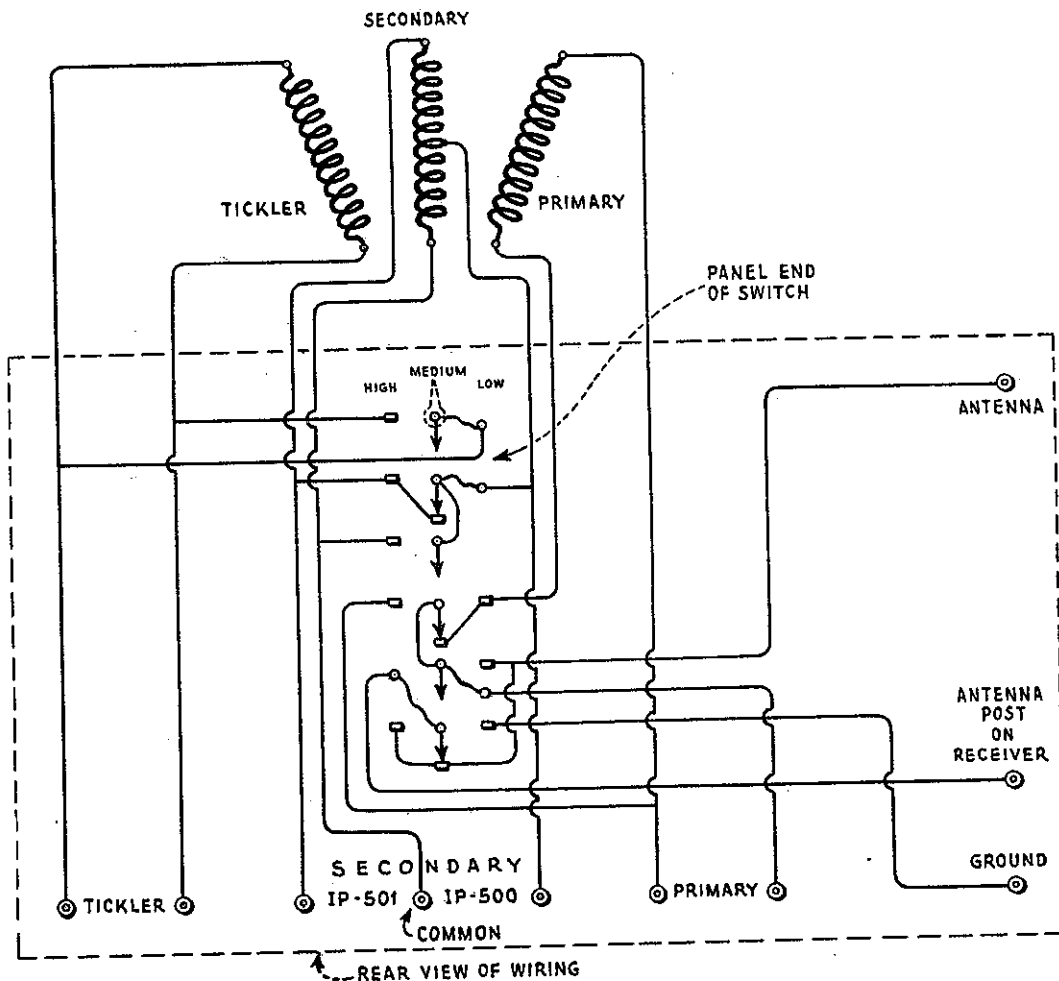


Figure 5

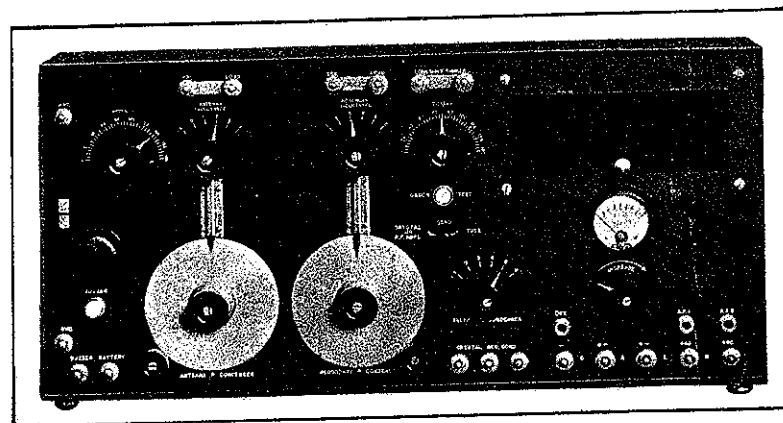


Figure 6

energy and are grounded as indicated by the diagram. The coupling between the circuits is purely electromagnetic and depends upon the degree of coupling as determined by the angular relationship existing between the movable secondary coil and the primary inductance.

Tickler Coil for Regeneration and Beat Reception. The tickler coil is connected in series with the detector tube plate circuit and is mounted at the short wavelength end of the secondary inductance. The tickler inductance, sometimes known as the rotor, is wound on a ball-shaped form, small enough in diameter to rotate within the tubing on which the secondary turns are wound. The coil is mounted on a shaft controlled by the rotary switch knob on the panel marked "Tickler," with the scale graduated from 0 to 180 degrees.

The inductive relation between the tickler and secondary being controllable, and being dependent upon the relative position of the two windings, allows a close regulation of the amount of energy which feeds back, or is transferred back, from the plate circuit to the grid circuit. The action of the tickler coil is briefly as follows: When signal oscillations are induced into the secondary circuit from the primary, the grid is charged with an alternating voltage which causes the plate current to pulsate at a similar frequency. The rise and fall of plate current in the tickler coil induces an alternating e.m.f. in the secondary because of the mutual inductance existing between the two circuits. The mutual inductance is variable by changing the angular positions between the coils when the tickler is rotated.

The signal energy is now re-introduced into the grid circuit. The e.m.f. induced in the secondary charges the grid with an alternating e.m.f. causing the plate current to again rise and fall, but at a much greater value, for we know that a small grid voltage variation will be repeated in the plate circuit with correspondingly large plate current pulsations. This is due to the inherent amplification characteristics of the vacuum tube.

The function of the tickler coil may be classified according to the two processes that take place, namely;

First, to provide for amplification of the signal by transferring part of the power in the plate current alternations produced by the incoming oscillations back into the grid circuit. This process is called "regenerative amplification" and the circuit will respond efficiently, when in this condition, to damped waves of the spark transmitter, or modulated continuous waves (C.W.).

If a regenerative detector is set into self-oscillation when damped oscillations such as those generated by spark transmitters are being received, only partial beats are formed by the combining of the two sets of oscillations. Although amplification is secured, complete beat formations, such as are produced from continuous wave signals, cannot be obtained because of the damping and discontinuity of the spark wave. The normal note of the spark transmitter is distorted, and a beat note of a rough quality is heard.

When spark signals are to be received, the coupling should be carefully adjusted to the verge of oscillation; i.e., only close enough to re-enforce the plate current alternations through the feed-back action, but not sufficiently great to set the tube into oscillation. In other words, the circuit should be

operated as a regenerative amplifier, and not as a regenerative beat receiver.

Secondly, if the tickler coupling is increased to a point where the plate energy transferred to the grid is greater than the energy which is lost in the grid circuit due to its oppositions, such as resistance, etc., then the tube will become retroactive, and generate oscillations of radio-frequency. If the frequency of these locally generated oscillations is slightly different from the signal frequency the two alternating currents will combine or heterodyne to produce a "beat current," which will set up vibrations in the telephone diaphragms. This process is known as "regenerative beat reception," and enables the receiver not only to carry out the function of regenerative amplification, but permits reception of continuous wave signals.

The explanations and suggestions relating to primary and secondary coupling and proportions of inductance and capacity used to secure selective tuning, which have been discussed in previous lessons, are equally applicable to this circuit.

The buzzer circuit consists of the push button switch, (the buzzer mounted at the left of the panel) an external battery of about three volts connected to the binding posts marked "Buzzer Battery," and a small coil of inductance coupled to the antenna lead as shown in the diagram. When the current flowing in the buzzer circuit is interrupted at each make and break of the circuit, as by the opening and closing of the contact points, the induced e.m.f. of self-inductance excites the circuit carrying the buzzer inductance, causing the latter coil to radiate groups of damped oscillations sufficiently strong to affect the antenna circuit.

Each impulse causes the antenna or primary circuit to oscillate at its own natural frequency, which of course depends upon the tuning adjustments, and a buzz or note will be heard in the receivers. The buzzer may then be used to adjust a crystal, if one is used as in the case of an emergency, or it will serve to indicate when the vacuum tube is oscillating, in which case a low hissing sound will be heard.

The "stopping" or telephone condenser is a mica condenser, variable in five steps by the rotary control switch mounted on the panel. When the correct capacity is found the groups of damped oscillations from a spark transmitter will discharge through the telephones with a large cumulative effect.

The grid condenser of 0.00025 mfd. capacity and the grid leak resistance shunted across the condenser allows the excess accumulation of electrons stored up on the grid during a group of oscillations to leak off and restore the grid to its normal negative potential. The function of the grid condenser is to place a negative potential bias on the grid to produce a large audio-frequency average variation of plate current, resulting in a greater deflection of the telephone diaphragm.

The impedance or iron core reactance coil shown in the diagram is connected in series with the telephone windings and it acts to build up the e.m.f. of self-induction caused by the audio variation of current passing through the telephone circuit, thus giving a strong signal. However, with very high resistance telephone receivers it is possible to accomplish this result without the reactance coil, but such head-sets possessing the proper impedance are not always available.

A small fixed condenser acting as a "by-pass" condenser is shown in the diagram to the right of the variable stopping condenser. By following out the continuity of the circuit it can be seen that when the four-pole double-throw control switch is in the "Crystal" position the fixed condenser and stopping condenser are connected in series and shunted across the reactance coil. Refer to Figure 2.

Let us observe the circuit arrangement when the control switch is moved to the "Tube" position. Both condensers are still connected in shunt with the reactance coil, but from the common point, which joins them in series, another lead is carried to the filament circuit. This places the condensers across all of the external impedance in the plate circuit represented by the reactance coil and the magnet windings of the receivers. The function of the condensers is to provide a low reactance path for the high-frequency alternating component of the plate current to flow through and dissipate this energy. By removing this oscillating energy, or high-frequency alternating component immediately after the incoming signals oscillations have acted upon the detector tube, it allows only the direct current, carrying the audio-frequency variations, to pass through either the telephone receivers, or a two-stage audio amplifier unit.

If, however, there is no means provided for the dissipation of the high-frequency component it will pass through the path formed by the distributed capacity of the windings. Under such conditions these parasitic currents, which they now become, may be carried along with the audio-frequency currents and perhaps mar the perfect reproduction of the original signal wave, or create disturbances in the audio circuits.

Practical Operation of the IP-501 Receiver

- (1) When the vacuum tube detector is employed move the control switch to the right, to "Tube," (sometimes marked "Audion.")
- (2) The rheostat should be in the "Off" position before operation (1) is performed. Now increase the filament current by moving the control handle in the direction marked "Increase" until the filament voltmeter indicator is on 5 volts.
- (3) For short wave work set the secondary inductance pointer at division 2, and for long waves at division 4, and for the reception of Spark signals the Tickler should be set at about 120 degrees. In any event the tube should not be oscillating, but in a condition for regenerative amplification when receiving spark or modulated C.W. signals.
- (4) To pick up a signal, increase the coupling and adjust the Antenna Inductance in steps and for every change swing the Antenna Condenser entirely across the scale. After the signal is heard, loosen the coupling, and tune the secondary circuit to resonance with the primary by means of the Secondary Inductance and Secondary Condenser.
- (5) Adjust the telephone condenser until maximum signal is heard, bearing in mind that the highest selectivity on spark signals is obtained by using a minimum amount of capacity in this condenser.

(6) Note, that for "Stand-By" adjustment, or pick-up work, the coupling between primary and secondary should be close, but for selectivity the coupling should be reduced to a point consistent with satisfactory reception.

Operation For Continuous Wave (C.W.) Reception

(1) Throw the control switch to "Tube" and increase the filament current until the voltmeter reads 5.0 volts.

(2) Adjust the Tickler coupling control to about 45 degrees and set the stopping or telephone condenser at point 3 or 4 cutting in about half of its capacity.

(3) The tube should now generate oscillations, which can be easily determined when a clicking sound is heard in the receivers while applying the following tests:

(a) When the push button marked "Osc'n Test" is depressed the tickler coil is shorted and consequently no inductive feed-back action will take place; hence, every time the button is pressed the oscillations will cease, being manifested by the phone click.

(b) When the antenna circuit is brought into resonance with the secondary by tuning with a medium amount of inductance coupling between the circuits.

(c) When the tickler coupling is tightened (periodic clicks.)

(d) If the tube is oscillating and the test buzzer is operated, a soft hissing sound will be heard.

(4) Set the coupling control, marked "Coupling," at about 80 degrees.

(5) Adjust the Antenna Inductance and vary the Antenna Condenser until the antenna system is in resonance with the desired signal wave, following the general procedure for tuning in spark signals. However, in C.W. reception the signal is often tuned in and out with a small variation in capacity and therefore the condenser should be rotated very slowly. For every change in the capacity of the primary or antenna condenser, the secondary condenser should be slowly rotated back and forth and each time the point is reached when the secondary is tuned to resonance with the primary it will be marked by a slight click heard in the phones. Continue varying the primary capacity slowly and for every change swing the secondary condenser back and forth past the resonant point until the characteristic C.W. note of the station is tuned in. The pitch of the note can be altered to suit the individual ear but in practice it is found that the best note, one that is not too highly pitched, is heard at a setting slightly above or below the resonant point.

(6) Loosen the tickler coupling as much as possible to obtain selective reception of C.W. signals and also use the loosest (minimum) inductive coupling between the primary and secondary.

(7) Failure to obtain oscillations may be due to insufficient tickler coupling or the polarity of the "B battery connection may be reversed.

Type IP 501-A Receiver. This receiver, the front view of which is shown in Figure 6, comprises an inductively coupled tuner, a vacuum tube detector, and two-stage audio amplifier. Except for the compact grouping of these components in one cabinet, this receiver differs only slightly from the well known IP 501 receiver.

Type 106D Commerical Receiver. The type 106-D Receiver is of the inductively coupled type, having independent primary and secondary circuits, both of which must be tuned to resonance with the wavelength of the desired signal. The fundamental diagram of the receiver is shown in Figure 7. The front panel view showing the tuning controls is illustrated in Figure 8, and the rear view photograph in Figure 9. The sketch, Figure 10, shows the mechanical arrangement of the various pieces of apparatus.

The vacuum tube detector and two step audio amplifier unit is mounted in a separate cabinet, connections being made from the main receiver panel to the vacuum tube circuits by the four leads indicated on the diagram with letters F, G, T1 and T2.

Antenna or Primary Circuit. The primary circuit consists of the antenna, an inductance made variable by two multi-point switches, a variable air type condenser (which may be automatically connected in and disconnected from the circuit), the secondary coil of the buzzer transformer, and the ground conductor.

Inserting the primary condenser in the antenna system shortens the wavelength of the antenna to a value less than its fundamental wavelength.

The winding of the primary inductance is tapped at each of the first ten turns with the leads connecting to the "Units" switch. The remainder of the coil is tapped in steps of ten turns and leads carried to the "Tens" switch. The main primary inductance is included between contact studs "0" and "190," indicated by the "Tens" switch. When this switch blade is placed on studs marked from 190 to 290 a separate loading coil is inserted in the circuit. This coil is shown mounted on the bottom board in the rear view panel photograph.

By manipulating both "Units" and "Tens" switches of the transformer primary any number of turns on the entire inductance as well as the loading coil may be used. The "Tens" switch is equipped with three copper segments or drums which rotate with the shaft. These drums act to disconnect and open entirely the individual sections of the inductance which are unused. A switch of this type is called an "end-turn" or "dead end drum" switch. Its use aids in minimizing losses of radio-frequency currents which occur when the unused portions of the inductance remain in the circuit, and it also tends to lessen interference. Sharper tuning results, because the self-inductance of the used portions is then only slightly altered by the presence of the unused sections of the coil.

The end-turn switch breaks the winding into groups for different ranges of frequencies. Such a switch, however, does not wholly eliminate all of the losses incurred due to the presence of the unused turns. The undesirable effects of the unused turns can be overcome only by removing them completely from the magnetic field set up around the used turns. This is an impractical consideration in a commercial short and long wave receiver.

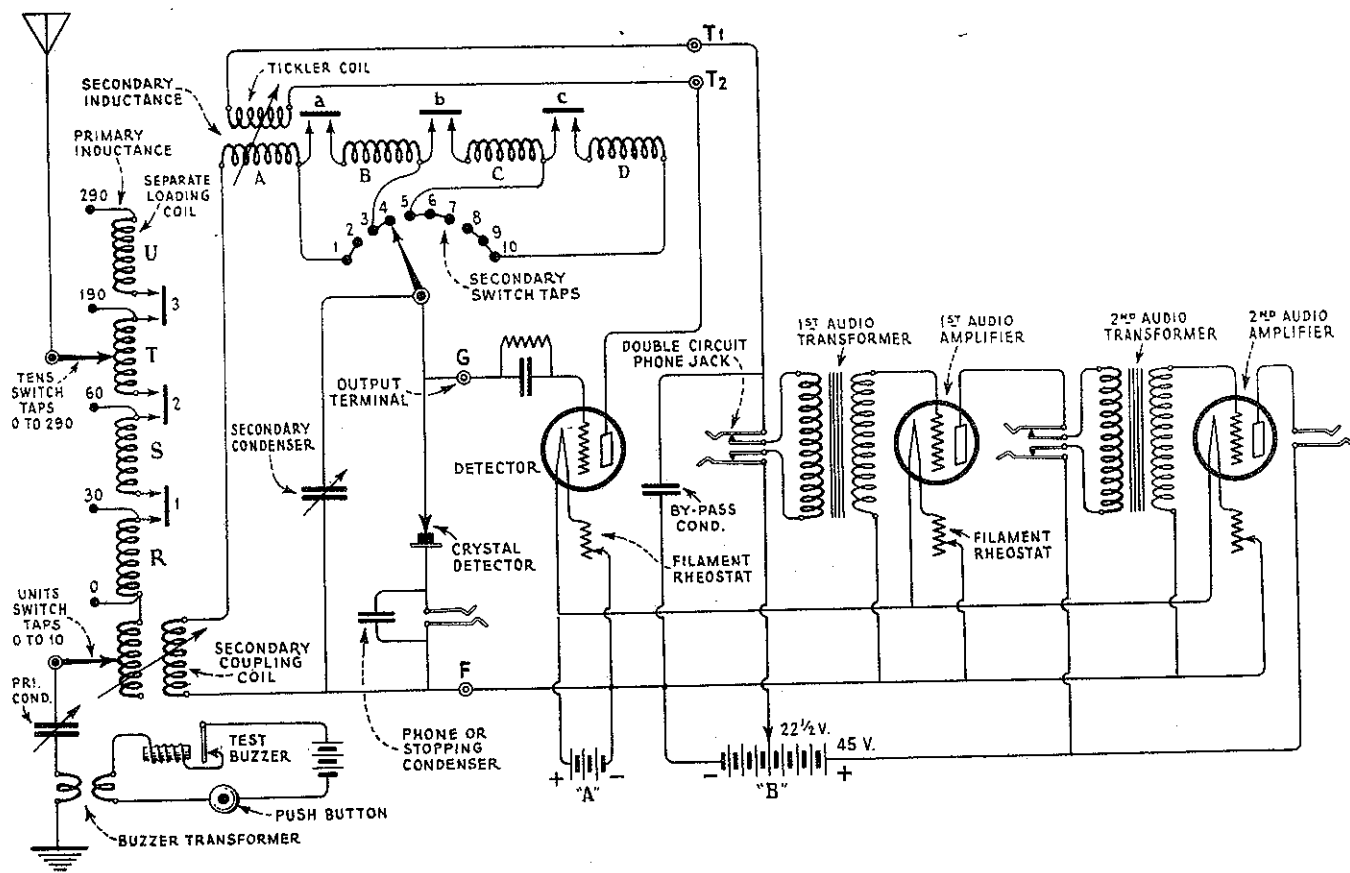


Figure 7

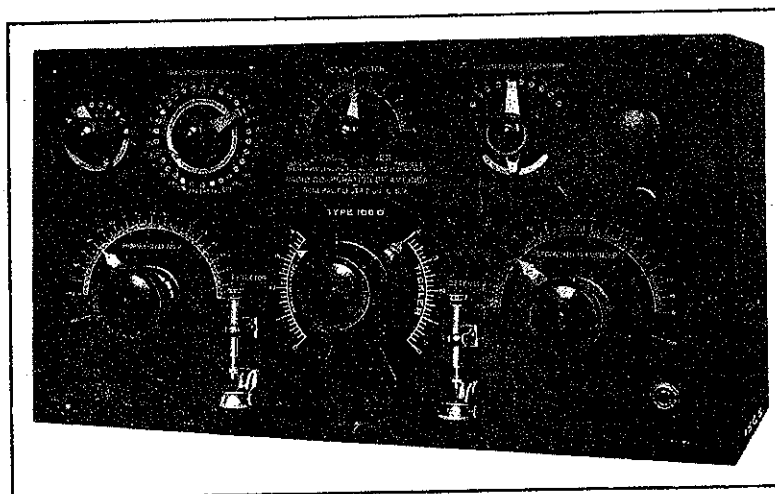


Figure 8

The copper segments (drums) are staggered on the shaft in such a way that when the "Tens" switch is on stud 30, the segments 1, 2 and 3 are disconnected from the primary inductance sections S, T and U, and hence at this time, only section R and the "Units" section remain in the antenna circuit. When the "Tens" switch is on stud 60, segment 1 is then in a position to connect section R with S, but segments 2 and 3 will be in a position to disconnect sections T and U.

With the "Tens" switch on 190, sections R, S and T are connected in the circuit while the loading coil, section U, is disconnected. With the switch on stud 290, segments 1, 2 and 3 make contact with the respective ends of every section and the entire inductance is then cut in; i.e., added to the circuit.

The primary condenser is connected in series with the antenna circuit and provides a fine variation of tuning. It is often used on the longer waves, even at a sacrifice in signal strength, in order to increase the selectivity of the receiver. To disconnect the primary condenser from the circuit, the dial should be rotated to the position marked "Out" on the front of the panel.

Secondary Circuit. The secondary circuit consists of the secondary inductance mounted on the base board of the receiver in a position at right angles to the primary inductance, the secondary tuning condenser which is shunted across the used portions of the secondary coil, and the detector. The secondary is wound in four separate sections or groups as the photograph clearly shows, and these sections are only connected together when increasing the wavelength by the segments of the "dead-end" switch, which is mounted on the shaft of the "transformer secondary" switch.

Coupling. The mutual inductance between the primary and secondary is affected by a 30 turn movable coupling coil which is part of the secondary inductance. The coupling coil is mounted at the short wavelength end of the primary inductance, the movement of the coil is controlled by the smaller of the two coupling knobs on the panel. The inductive relationship of the primary and secondary depends upon the angular relationship between the two inductances. To secure minimum coupling the coupling coil is turned at right angles to the primary indicated by "0" on the dial scale. The position of the coupling coil in the photograph is one very near to that of minimum coupling.

To obtain maximum coupling the coil is rotated to occupy a position within the cylindrical tubing upon which the primary is wound. The electromagnetic induction between the two circuits will be maximum when the center axes of the two coils lie in the same plane. At the position of maximum or close coupling it can be seen that the winding on the coupling coil will be parallel to and closest to the primary winding, indicated by "4" on the dial scale.

The secondary inductance is not tapped between the sections A, B, C and D. Each section is added to the circuit in progressive order by the segments a, b and c of the "dead-end" drum switch when the switch arm of the transformer secondary is placed on contact studs 1, 3 and 5 respectively, indicated on the panel. Although there are ten studs to permit of smooth rotation of the lever arm only the three studs mentioned actually cut in the four sections of the inductance. Studs 1 and 2 are shorted together, acting in effect as one stud, as are 3 and 4; also 5, 6 and 7, and similarly 8, 9 and 10. With this arrangement the wavelength value is not changed when moving the secondary switch arm

from one stud to another stud if the studs are connected by a short-circuiting jumper. The extra studs are used as terminal lugs, making convenient connection of leads running from the ends of the secondary coil sections to the brushes resting on the segments of the mechanical "dead-end" switch.

The three segments on the secondary switch used to disconnect the unused sections of the secondary inductance are shown in the rear view photograph of the receiver. The mechanical construction of the segments is shown in Figure 11.

The secondary tuning condenser remains in the circuit at all times and permits a close and continuous variation of the frequency of the secondary.

Tickler Coil for Regeneration and Beat Reception. The tickler system consists of a movable coil mounted at the top of the secondary inductance, close to the first section A, which is the short wavelength end of the coil. The diagram shows that this section always forms part of the secondary inductance, being connected to contact stud 1 on the transformer secondary switch.

The tickler coil is connected in series with the plate circuit of the vacuum tube detector, through binding post T1 and T2 on the terminal board of the receiver. The inductive relationship between the tickler coil and secondary is controlled by the larger of the two coupling knobs on the front of the panel. The "feed-back of radio-frequency energy from the plate circuit to the grid circuit is maximum when the tickler is parallel and closest to the secondary, indicated by "4" on the dial scale. On the other hand, loosest coupling between the circuits is obtained when the tickler coil is rotated to occupy a position where its windings are at right angles to the secondary winding, indicated by "0" on the dial scale. The tickler coil is shown in the position of minimum coupling in the photograph.

Buzzer Circuit. The buzzer circuit is especially useful for testing the adjustment of a crystal detector, if one is used, as it might be in an emergency. It will be noted that the circuit provides for the connection of a crystal and is equipped with a stopping (telephone) condenser and phone jack.

The buzzer circuit may also be used to indicate when the vacuum tube is oscillating, in which case a low hissing sound will be heard in the receiver. If the tuning buzzer is set into operation by depressing the push button, the buzzer circuit is rapidly opened and closed by the make and break at the contact points of the armature. The magnetic field expanding and contracting about the buzzer coil of the buzzer transformer will induce oscillations into the antenna circuit at the natural frequency of the antenna. The secondary may then be tuned to resonance with the primary to receive the buzzer signal.

On account of the energy which is liberated each time the magnetic field around the magnet coils of the buzzer itself is changed, it is rather difficult to obtain a clear note when using the vacuum tube detector.

Vacuum Tube Circuits. The vacuum tube apparatus is mounted inside a separate case and, when connections are made with the main receiver, care should be exercised to obtain the correct tickler coil relation with the secondary. The tickler leads T1 and T2 should be reversed and tests made if there is any failure to obtain oscillations when the tickler is set at maximum coupling.

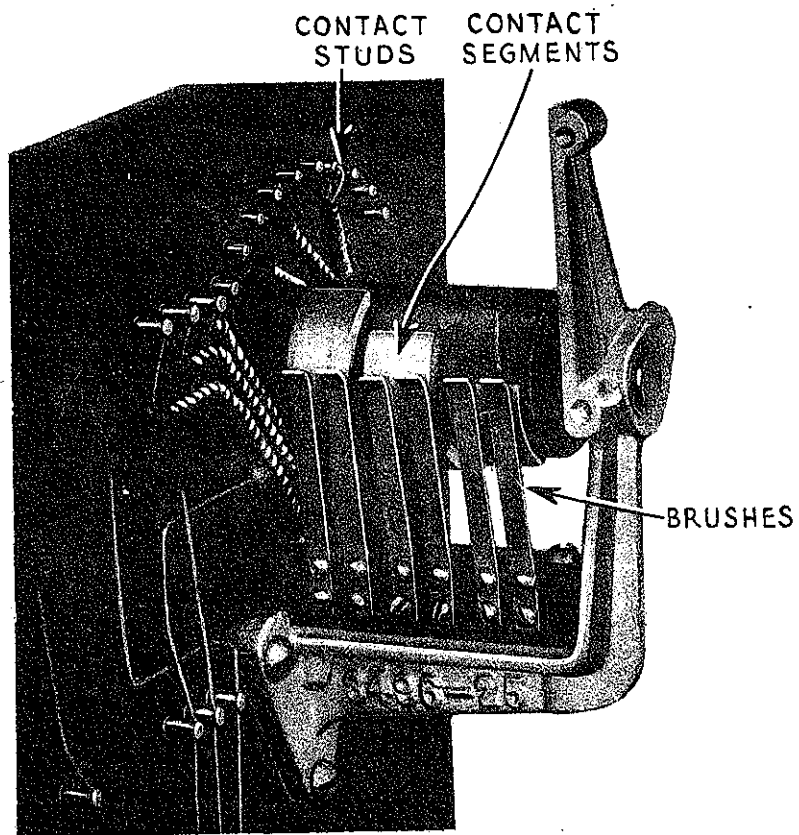


Figure 11

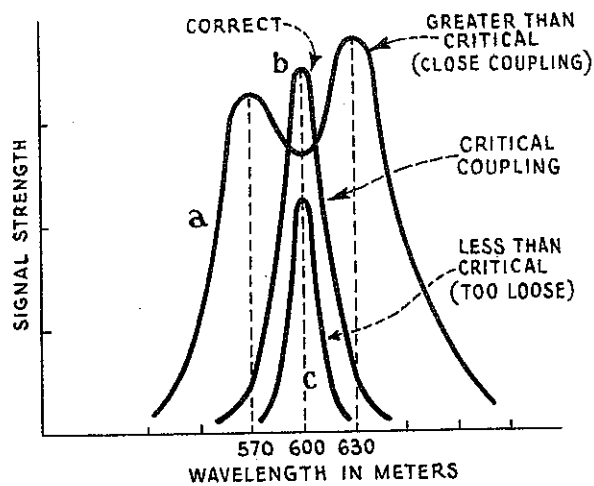


Figure 12

Each tube is provided with a current control filament rheostat, and each plate circuit is equipped with a phone jack, to permit weak signals to be amplified through one or two stages of audio amplification. If the signals have good audibility, however, they may be read directly in the output of the detector. When the telephone plug is inserted in either one of the double-circuit jacks, the outer two leaves will spread breaking contact with the two inside leaves, thus disconnecting the primary of the audio transformer from the plate circuit. The telephone receivers are then inserted in the plate circuit because the tip and shank of the plug make connection respectively with the outer leaves of the jack.

Operation of the Receiver. If the crystal detector is to be used, the phones should be plugged in the jack at the front lower right side of the receiver panel, provided for that purpose. The crystal should be adjusted to maximum sensitivity by means of the test buzzer. The filament switch for each vacuum tube circuit is to be in the "Off" position. When a crystal is used which does not require a battery, the potentiometer must be set at zero. However, when a battery operated crystal is used, such as carborundum, the potentiometer pointer is moved to either one side or the other past zero "0" position until loudest signals are heard, either from a distant sending station or from the test buzzer circuit. The critical point in the characteristic curve of the detector is reached when the potential applied to the crystal will cause the largest change in the current flowing through the telephone magnet coils for a given intensity of the incoming signal oscillations. The sensitive spot of the crystal is found by exploring its surface with the fine whisker wire.

If the vacuum tube detector is to be used, the crystal detector circuit must be open, and the phone plug removed from the jack in the vacuum tube panel. The detector filament rheostat is now turned to the right, cutting out resistance gradually, until the filament is lighted to normal brilliancy. Vacuum tubes employing the thoriated filament are operated at a lower temperature than the oxide coated filament type, and it is perhaps difficult to determine if the specified normal voltage has been applied to the filament terminals when a voltmeter is not available. In order that the filament wire will not be subjected to an excess current flow it is suggested that the rheostat be adjusted until a hissing sound is heard, after which the current should be reduced by increasing the rheostat resistance until the hissing disappears and a clarified sound is heard in the telephones.

Reception of Spark Signals. Regenerative Amplification. To receive spark (damped oscillations) or any modulated continuous oscillations, such as modulated C.W. of telegraphy or telephony, the tube circuit should not be in an oscillating condition. Hence, the tickler coil coupling is gradually increased, after the signals from a spark transmitter are picked up to increase amplification by the phenomenon of regeneration, but this amplification of the signal unfortunately can be carried only to the region just below the point at which critical coupling between the plate and grid circuits will cause the tube to break into oscillation. The tube circuit will then generate continuous oscillations and the spark signals will be slightly distorted into mushy sounds.

The receiver is in a "stand-by" adjustment to pick up the signals from a transmitter when the primary and secondary are closely coupled, affording broad tuning, indicated when the coupling pointer is set at "4" on the dial scale. The primary condenser is then set at "Out" and the amount of inductance in the primary and secondary is found by adjusting the multi-point switches.

In adjusting the receiver circuits to resonance with the signal frequency it should be borne in mind that the primary and secondary may have exactly the same fundamental frequency although using different proportions of inductance and capacity.

Ordinarily the loudest signals are obtained when the secondary circuit is formed with a minimum amount of capacity and a correspondingly large amount of inductance. However, it is possible at times to secure greater selectivity, and avoid interfering signals. This can be done working with the loosest coupling practicable between primary and secondary and then using small amounts of secondary inductance while tuning the circuit to resonance by means of the secondary condenser, until an easily readable signal is brought in. It should always be remembered that for any increase or gain in selectivity there will be some sacrifice in signal strength, and vice-versa.

In practice it is found that selectivity may be further increased by utilizing the primary condenser. The capacity of this condenser is placed in series with the distributed capacity of the antenna system and consequently the total capacity used for a given wavelength must be compensated for by using a larger amount of primary inductance. The intensity of the signal will be lowered somewhat, as will be experienced whenever the natural frequency of an antenna circuit is artificially altered by means of capacity inserted in series with the circuit.

The receiver has a range of wavelengths from 200 to 3,500 meters. The lowest wavelength range is obtainable when the primary condenser is used and the primary "Tens" switch is set at zero (0), while the primary "Units" switch is placed on stud 10, and at the same time using the lower points of secondary inductance. The primary condenser is slowly rotated until the signal is heard and, if at 180 degrees, the signal is still weak, it may then be necessary to add primary inductance in steps of "ten turns" as indicated by the "Tens" switch. A good rule to follow with each change in the primary inductance is to swing the secondary condenser slowly back and forth once across the scale, for we must at some time pass the point of resonance where the circuit will respond to the signals.

The primary and secondary must be in resonance to receive the loudest signal, and since the strength of the signals is the only indication we have that the receiver is in tune with the incoming signal wave it is imperative to fully understand the effects of close and loose coupling and the proportions of capacity and inductance used in the two oscillatory tuned circuits.

Reception of Continuous Waves (C.W.) Regenerative Beat Reception. To receive continuous wave (C.W.) signals from either an arc transmitter, or vacuum tube transmitter, the tickler coupling is adjusted to the point where the "feed-back" energy from the plate circuit to the grid circuit is sufficient to maintain oscillations. The coupling should not be any closer than is consistent with a good audible signal. Upon reaching this point of oscillation the usual indication is a pronounced click in the telephone receivers.

The antenna circuit is adjusted to resonance with the wavelength of the signals we wish to receive by the methods already explained for picking up spark signals.

The process of continuous wave reception is based upon the heterodyning or combining of two alternating currents having slightly different frequencies,

which provides the necessary "beat" current to which the telephone diaphragms will respond.

The frequency of the incoming oscillations is governed by the inductance and capacity of the distant transmitting antenna, and the maximum signal oscillations are induced in the receiving antenna when its circuits are in tune with the transmitter. In the case of continuous wave reception we know that the secondary, which is generating continuous oscillations at a frequency determined by its L C values (inductance and capacity values), must be tuned slightly out of resonance with the primary to produce the "beat" note.

As the secondary condenser is slowly rotated, it will be found in practice that a slight click will be heard when the resonant point is reached; that is, when the frequency of the locally generated oscillations coincide with the frequency of the signal oscillations.

Having accomplished this, we should now rotate the condenser dial to a setting slightly below or above the resonant point, until the clearest note is received. The pitch of the note is varied for each change in capacity, and the note best suited to the individual ear should be selected. Furthermore, interference may be minimized by changing the note or by loosening the coupling after we have picked up the desired station.

For any change in coupling between two oscillatory circuits, the mutual inductance is altered and the magnetic fields react upon the respective inductance coils in such a manner as to cause a variation in the self-inductance of each circuit. This, of course, throws the circuits slightly out of resonance and the signals are weakened. It is a simple matter to retune the set by adjusting first one circuit and then the other until all circuits are again in resonance, which is manifest when the signals are at their loudest.

The failure to obtain oscillations may be due to reversed tickler coil connections, or insufficient tickler coupling to maintain the tube in a state of continuous oscillation. After reaching the critical point where a tube falls into oscillation we should tighten the coupling; that is, increase the coupling with an adjustment of a few degrees beyond this point to promote a stable condition.

To test for oscillations the tickler coil coupling is varied from minimum to maximum several times and it should be accompanied by periodic clicks in the headphones. Also, the secondary switch may be tapped with the finger, preferably moistened, when the added "body capacity" will destroy the resonance of the circuit.

If the tube is oscillating, a click will be heard each time the finger makes contact with, or is removed from the switch blade.

It is advisable to frequently check up on the polarity of the "B" battery connections which supply the positive plate potentials for the vacuum tubes, and also to test the "B" voltage. A partially run down "A" battery may not supply sufficient voltage to the tube for obtaining oscillations.

It is necessary in any receiver equipped with switch blades and contact studs to make an occasional inspection for perfect contact and a good firm pressure.

between them. A weak pressure can be remedied by removing the screw in the center of the knob, pulling the knob off of the shaft, and removing the screws which hold the switch blades in place. The blades may be bent to secure the proper tension and replaced. Undue tension should not be brought to bear between the blade and studs because a groove will be rapidly cut in the studs, causing unnecessary wear.

Proper Adjustment of Coupling. Radio operators know that loose coupling gives greatest selectivity and sharp tuning. Many operators believe loose coupling also means reduction in signal strength. This is not necessarily true. For every wavelength within the range of the receiver there is a degree of coupling which will give the most satisfactory results from the combined viewpoint of signal strength and sharpness of tuning. This is called "Critical Coupling." Figure 12 illustrates how selectivity and received signals vary for different degrees of coupling. The conditions (coupling) under which these curves were taken with the tickler at zero, and with both primary and secondary circuits tuned to 800 meters, are marked on each curve. The conclusions drawn from Figure 12 are as follows:

1. The looser the coupling, the sharper the resonance curve (the greater the selectivity) but looser than critical coupling considerable reduces the signal strength.
2. Close coupling makes the receiver resonant to two wavelengths at the same time; one below and one above the desired wavelength, 800 meters.

Critical coupling occurs at that adjustment at which the primary circuit produces no reaction on the secondary. This fact fortunately makes it easy for the operator to test the receiver adjustment to ascertain if the coupling is approximately at this desired critical value.

To Test For Critical Coupling. Assume the secondary condenser is set at the desired wavelength. Advance the tickler slightly beyond the oscillating point. Rotate the primary condenser slowly back and forth, noting the "double click" in the telephones as the primary passes through resonance with the secondary circuit. As the coupling is loosened these "double clicks" will merge into one faint click. At this setting the receiver is adjusted for critical coupling. Observe that the value of critical coupling changes with wavelength.

"The Double Click" is familiar to operators of oscillating receivers. This sound in the telephones results from the sudden change of plate current when the detector stops and starts oscillating due to the primary wavelength being varied through that at which the oscillating secondary is set. The greater the distance on the primary condenser dial between these "clicks" the closer the coupling between the circuits.

Before we obtain this "double click" indication, we must have: (a) the antenna connected so that the primary circuit is complete and can be resonated to the secondary; (b) the tickler so set that the detector oscillations are neither too strong nor too weak; (c) the coupling adjusted to be at least greater than critical.

EXAMINATION - LESSON 56

1. Draw a schematic diagram of the type IP-501 commercial receiver and label the parts.
2. In concise tabulated form write all of the steps necessary to place the IP-501 receiver in practical operation to receive a C.W. signal.
3. In brief, how should the receiver be adjusted first to tune in a spark signal, and second, to tune in a C.W. signal?
4. (a) How is the tickler coil connected and in general what position should it occupy to provide maximum "feed-back" of plate energy? (b) If the circuit failed to oscillate what do think might be the probable cause or causes? (c) Suppose you are on a radio watch and your receiver is tuned to pick up a distant spark station and the signals came in with considerable distortion. What do you think would be accountable for this condition and how would you remedy it?
5. (a) Are there any practical considerations in regard to the amounts of inductance and capacity to be used in the tuned circuits when manipulating the control knobs to tune in a signal? (b) Is it of any particular advantage to know the theoretical operation of a tuned circuit in order to be capable of adjusting such a circuit to the best advantage in commercial operating? Explain briefly.
6. (a) Is it always necessary to employ extreme close coupling between primary and secondary to obtain a good readable signal? Why? (b) When is the series antenna condenser used and how may it be cut out of the circuit?
7. Give some general advice in regard to tuning a commercial receiver to a certain incoming signal. (Be brief in your reply but answer this question as though you were instructing a fellow-operator in the best practical methods necessary to accomplish this important assignment).
8. (a) What is meant by "stand-by" adjustment? (b) How is coupling altered? (c) What causes the "double-click" heard in the phones and how does this test for critical coupling?
9. (a) What elements comprise the primary and secondary circuits of the type 106-D commercial receiver? (b) What is a "dead-end" switch and of what practical value is it? (c) Should it be examined occasionally and why? (d) What are the two control knobs located directly in the center of the front panel of the 106-D receiver?
10. Draw a schematic diagram of the type 106-D receiver and label the parts.